Impact of COVID-19 Pandemic on Laboratory Utilization

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Abbreviations:
ACE2: Angiotensin-converting enzyme 2
COVID-19: Coronavirus Disease 2019
cTnT: cardiac troponin T
FDP: Fibrin degradation products
GAS: group A *Streptococcus*
LIS: Laboratory information system
INR: International normalized ratio
ISTH: International Society on Thrombosis and Hemostasis
MRSA: Methicillin resistant *Staphylococcus aureus*
NT-proBNP: N-terminal pro-brain natriuretic peptide
PT: Prothrombin time
PTT: Partial thromboplastin time
POC: Point of care
RVP: Respiratory viral panel
SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2
TAT: Turnaround time
VTM: Viral transport media

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Background: Coronavirus Disease 2019 (COVID-19) was formally characterized as a pandemic on March 11, 2020. Since that time, the COVID-19 pandemic has led to unprecedented demand for healthcare resources. The purpose of this study was to identify changes in laboratory test utilization in the setting of increasing local incidence of COVID-19.

Methods: We performed a retrospective assessment of laboratory test order and specimen container utilization at a single, urban tertiary care medical center. Data were extracted from the laboratory information system database over a 10-week period, spanning the primordial inflection of COVID-19 incidence in our region. Total testing volumes were calculated during the first and last two-weeks of the observation period and used as reference points to examine the absolute and relative differences in test order volume between the pre-pandemic and COVID-19 surge periods.

Results: Between February 2, 2020 and April 11, 2020, there were 873,397 tests ordered and final verified. The in-house SARS-CoV-2 PCR positivity rate for admitted patients in the last week of the observation period was 30.8%. Significant increases in workload were observed in the send-out laboratory section and for COVID-19 diagnosis (PCR) and management-related testing. Otherwise, there was a net decrease in overall demand across nearly all laboratory sections. Increases in testing were noted for tests related to COVID-19 management. Viral transport media and citrated blue top containers demonstrated increases in utilization.

Conclusion: Increasing local incidence of COVID-19 had a profound impact on laboratory operations. While volume increases were seen for laboratory tests related to COVID-19 diagnostics and management, including some with limited evidence to support their use, overall testing volumes decreased substantially. During events such as COVID-19, monitoring of such patterns can help inform laboratory management, staffing, and test stewardship recommendations for managing resource and supply availability.

IMPACT STATEMENT

- In this report, we characterize observed changes in the demand for laboratory testing following the COVID-19 outbreak at a tertiary care clinical laboratory near one of the US epicenters of the pandemic.
- These data provide an overview of utilization changes laboratories may anticipate in response to increasing COVID-19 incidence in their region and may provide guidance on how these changes may impact operational decision making.
- We found an overall decrease in laboratory test volume, but there were striking increases in demand for COVID-19-related testing. In addition to tests for SARS-CoV-2 itself, increases were seen for tests related to COVID-19 management, including those associated with coagulopathy, myocardial stress/injury, host immune dysregulation, and prognostic indicators in the setting of multiorgan dysfunction and sepsis.

INTRODUCTION

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has resulted in an unprecedented change to the use of modern healthcare resources, including new demands for patient care and the clinical laboratory. Since first being reported in December 2019 in Wuhan, China, the global incidence of coronavirus disease 2019 (COVID-19) has increased exponentially, and on March 11, 2020 COVID-19 was characterized as a global pandemic.(1,2) (3) This rapid increase in cases and subsequent need for specialized testing has dramatically affected clinical laboratory testing, including the swift development of new assays, requirements for highly-trained personnel, management of reagent and supply shortages, and risk of staffing short-falls due to COVID-19 infection.

With a new and rapidly spreading disease, the clinical laboratory is challenged to meet the diagnostic needs of patients and providers in an environment with investigational and evolving treatment and monitoring strategies. As COVID-19 is an acute illness with a contagious pathogen, quickly and accurately providing diagnostic results is crucial to guide therapy and triage and manage patients to limit the spread of community and nosocomial infections. However, at the time of this writing, there are no consensus recommendations for laboratory testing in the management of COVID-19 beyond what is required to obtain a formal diagnosis. There is also a paucity of literature to demonstrate the value of specific laboratory tests which may be useful for identifying hospitalized patients with COVID-19 who are at risk for severe illness or decompensation.(4,5)

To date, there is scarce information about the demands placed on clinical laboratory resources outside of COVID-19 specific diagnostics, although reports are beginning to emerge.(6,7) As a result, laboratory directors remain largely unguided about the expected demand for laboratory services and the clinical utility of requested assays in the context of this novel disease. Here, we detail our real-world experience within the clinical laboratory of a large academic healthcare system near one of the US

epicenters of COVID-19. We describe the laboratory utilization trends that resulted from an influx of COVID-19 cases, with the goal of providing information related to diagnostic test use, needed reagents, and staffing requirements for the laboratory.

METHODS

Data Collection

Retrospective laboratory test order and result data were extracted from our laboratory information system (LIS)(Beaker; Epic, Madison, WI). Record-level data consisted of test orders that had a final verified result. Additional metadata included procedure name, procedure code, ordering department, laboratory resulting section, and specimen received time. Default collection containers were extracted from the LIS for analysis of specimen container type utilization. All laboratory tests were performed at a single, urban tertiary care medical center, which consists of 1,541 licensed beds on two campuses. This work was part of an IRB-approved project within our department (IRB Protocol ID: 2000027747).

Data Analysis

Frequency of laboratory test orders were collated into weekly buckets based on the date the specimen was received to reduce the typical variation seen in testing volumes on different days of the week. Absolute and percent change in number of test orders and container types were analyzed prior to (February 2nd to April 11th) and after the time SARS-CoV-2 PCR testing becoming available on March 8th, 2020. Total testing volumes were calculated during the first and last two-weeks of the observation period. These totals were used to calculate the absolute and relative differences in test order volume between the pre-pandemic and COVID-19 surge period. Orders were collated into groups based on the

laboratory section performing the related assay – e.g., hematology, chemistry, microbiology, etc. Of note, our laboratory has separate sections for virology and microbiology, so PCR testing for COVID-19 is reflected in counts for the virology section, rather than microbiology. Orders were also organized by patient status (inpatient, outpatient, and emergency department) based on the collecting department. Custom Python (version 3.7.4) scripts were used to obtain counts of container types by linking laboratory test orders to the 'default' container type defined in the LIS.

RESULTS

COVID-19 Incidence and Laboratory Utilization: Between February 2, 2020 and April 11, 2020, there were 873,397 tests ordered and final verified. This period of observation was chosen based on an inflection of SARS-CoV-2 PCR testing which we noted during the week of March 8th (Figure 1A). Among these tests, 58.6% (n=511,403) of orders were from inpatient wards, 25.5% (n=223,392) were outpatient, and 15.9% (n=138,602) were from the emergency department. During the final week of the observation period, SARS-CoV-2 positivity rates by PCR testing were 30.8%, 38.0%, and 36.9% in the inpatient, outpatient, and emergency department settings, respectively. All laboratory sections demonstrated an initial decline in testing volume between the weeks of March 8th and March 15th: send-out laboratory, -18.3%; core laboratory, -27.6%; BG/POC testing, -19.5%; blood bank laboratory, -23.5%; microbiology laboratory, -33.2%; virology, -29.4%, and specialty testing, -46.5% (Figure 1B/1C). Following the initial decrease in test volumes, test volume remained lower in all laboratory sections relative to the pre-pandemic state. The most notable exception was the increase send-out test volume which, following an initial decrease of 18.3% during the week of March 15th, was ultimately observed to experience a 65.6% increase relative to the pre-pandemic baseline (Figure 2).

Impact of COVID-19 on Laboratory Section and Individual Tests: Laboratory section-level data indicated that overall order volumes had sustained decreases in all sections except for the send-out laboratory and tests performed on blood gas analyzers, the latter of which includes both point of care (POC) and central laboratory testing. As shown in Figure 2, molecular diagnostics (-76.3%), immunology (-66.5%), and flow cytometry (-60.7%) experienced the largest declines in order volumes.

Absolute and relative differences between the total number of orders in the first two and last two weeks of the observation period were used to assess overall change (Table 1). We found an overall decrease in laboratory test volume by 14.8%, but notable increases were observed among biomarkers used to monitor host immune response, cardiovascular status, and hemostatic abnormalities. We also analyzed tests that are commonly ordered in the setting of respiratory tract infections. Of these, procalcitonin, arterial blood gases, *Influenza A/B* PCR, PCR for methicillin resistant *Staphylococcus aureus* (MRSA), and antigen testing for *Streptococcus pneumoniae* (*S. pneumoniae*) and *Legionella* were all observed to have an increased inpatient volume (Table 2). Of note, the number of orders for blood cultures was observed to decrease by approximately 40% across all patient settings.

Change in Use of Consumables Due to COVID-19: Of the containers associated with the test orders in this dataset, viral transport media (VTM) and citrated blue top containers were the only two with a marked increase in use over the last two weeks compared to the first two weeks in the analysis period (Table 3). Light green top tubes and blood spots showed operationally equivocal differences in use. The other container types showed a decrease in overall utilization (Table 3). Of note, use of blood gas syringes were shown to decrease by 21.7% while ordering of 'blood gas' tests were increased by 16.7%.

DISCUSSION

The COVID-19 pandemic has resulted in unprecedented demand for healthcare resources. As prevalence of the disease has rapidly increased worldwide, there are a growing number of reports describing

preparedness and response strategies for the anticipated surge of patients with COVID-19, particularly in critical care settings.(8–10) However, there are currently no reports that describe the effect of the COVID-19 pandemic on laboratory operations. In this study, we summarize the observed changes in laboratory test utilization from a single, urban tertiary care medical center near one of the US epicenters of COVID-19 which, at the time of this writing, had a SARS-CoV-2 PCR positivity rate of 30.8% for admitted patients.

Like most institutions, we postponed elective ambulatory surgical procedures and transitioned many outpatient appointments to telehealth visits. Additionally, both our inpatient census and ED visit volume are reduced compared to volumes prior to the COVID-19 pandemic. These factors are reflected in the decreased ED and outpatient testing volumes. At our institution, all laboratory sections that perform clinical testing experienced a sustained decrease in order volume. However, the send out section experienced a marked increase in overall workload. More than 80% of this difference in order frequency was attributable to sending three tests to reference laboratories: SARS-CoV-2 PCR, a multiplex cytokine panel, and angiotensin II levels. Send out testing for SARS-CoV-2 PCR was almost completely comprised of ambulatory patients, whereas inpatient testing was directed to in-house testing to facilitate the needed rapid turnaround time (TAT) for clinical decision making for more severe patients.

Cytokine and angiotensin II levels are analytes with recent evidence that suggests a correlation with clinical deterioration in patients with COVID-19 or possible mechanistic relationship for infection, respectively. Because of the possible relationship between dysregulation of the host immune response and clinical decompensation, there are ongoing trials investigating the use of immunomodulatory agents.(11–14) However, the prognostic utility of cytokine assays for disease severity or response to immune modulation therapy is currently unknown and the use of clinical testing is likely limited outside of investigational use. Angiotensin II levels have even less evidence to support clinical testing. While

data indicate that SARS-CoV-2 gains entry to target cells through binding of the of the viral surface spike protein (S) with human angiotensin-converting enzyme 2 (ACE2) receptor (15) which is expressed on a multitude of cell types including cardiac tissue and type II alveolar cells in the lung, (16,17) there are currently no data to support monitoring and recent data suggests a limited role of ACE inhibition on risk of infection.(15,18–20) Of note, since the end of the study observation period, this ordering practice has largely abated at our institution.

Marked changes in coagulation testing were observed in the hematology laboratory with increases in D-dimer, fibrinogen, prothrombin time (PT), partial thromboplastin time (PTT), and international normalized ratio (INR). These have been among the most ordered laboratory tests during the COVID-19 outbreak in our region, with D-dimer orders increasing by 1,771% relative to pre-pandemic volumes. Not surprisingly, usage of citrated (blue-top) tubes have increased by 58.71% at our institution, and our laboratory is currently implementing ordering guidelines to protect and maintain this supply chain. In the subset of patients with COVID-19 who progress to multiple organ dysfunction, the development of coagulopathy is a prominent and poor prognostic feature, where markedly elevated fibrin degradation products (FDP) and D-dimer levels have been observed among non-survivors.(21,22) Accordingly, there are emerging recommendations, including interim guidance from the International Society on Thrombosis and Hemostasis (ISTH), which suggest closely monitoring D-dimer levels in admitted patients with COVID-19.(21,23) In addition to D-dimer, some also suggest monitoring PT, platelet count, and fibrinogen.(23,24)

In the clinical chemistry laboratory, we observed an increase in test orders for procalcitonin and lactate dehydrogenase, both of which have been associated with poorer prognosis in patients with COVID-19.(25,26) We also observed an increase in orders for 4th generation cardiac troponin T (cTnT) and N-terminal pro-brain natriuretic peptide (NT-proBNP). Myocardial stress is common among patients with severe respiratory illness, and elevations of troponin and natriuretic peptides predict a poor

prognosis in this setting.(27) Significant differences in levels of cardiac biomarkers for acute MI and heart failure have been observed between survivor and non-survivor cohorts with COVID-19.(17,28) However, the significance and etiology of these findings for the management of COVID-19 remains unclear. Accordingly, there is limited guidance on when to order these tests and how to use the results. Current recommendations from the American College of Cardiology recommend only ordering troponin and BNP if acute MI or heart failure are being considered on clinical grounds.(28)

Notably, container utilization data indicated a decrease in blood gas syringe usage relative to the pre-pandemic state. However, tests performed in the blood gas laboratory increased as did order volume for arterial blood gases among admitted patients. The discrepancy is likely due to the default container type of 'blood gas syringe' being mapped with other POC-tests such as activated clotting time, troponin I, and GEM 4000 blood gases, all of which had a decrease in order frequency (data not presented). This increase in blood gas testing however, did lead to low supplies of these consumables. At our institution, blood gas syringes are purchased and distributed throughout the hospital by central supply chain services and rely on each floor, unit, or crash cart manager to request more syringes when supplies are low. At the time of this writing, we are currently working closely with supply chain as our preferred and backup heparinized blood gas syringes are on allocation or backorder, and there has been a resulting shortage on specific units in our hospital. This is likely due to a multitude of factors including unit-specific usage rates and global supply chain issues, the former of which is poorly captured with hospital-level data exports using default container type as the surrogate data element.

Among ordering trends for respiratory pathogen testing, we observed a decrease in influenza A/B *PCR*, group A *Streptococcus* (GAS) PCR, and respiratory viral panel (RVP) orders. These declines likely reflect operational changes which were made in light of CDC recommendations that respiratory specimens from PUIs be processed in class-II biosafety cabinets.(29) Because of this, all respiratory specimens processed in the clinical laboratories were treated as though they were collected from a

patient suspected to be infected with SARS-CoV-2. Further, upper respiratory sampling was discontinued at outpatient practices. Future studies should assess for changes in clinical management (e.g. greater use of empiric antibiotics for GAS pharyngitis) related to a reduced laboratory formulary because of such changes in specimen collection and laboratory practice.

The reported incidence of COVID-19 is, in part, influenced by not only the availability of SARS-CoV-2 PCR testing capabilities, but also the institutional practice recommendations regarding diagnosis and screening. A laboratory stewardship team was formed early in the pandemic to translate national testing guidelines into local operations balancing the availability of different tests with clinical need and test performance characteristics including sensitivity and turn-around-time. During the observation period, there were system level initiatives to align testing strategies across inpatient, outpatient and ED settings, wherein the observed incidence of COVID-19 was 30.8%, 38.0%, and 36.9%, respectively. Institutional guidelines changed frequently and eventually recommended less restrictive testing practices. Early in the pandemic, the limited availability of testing capacity contributed to more restrictive ordering practices and these practices may have continued out of habit even after guidelines called for more wide-spread testing. Currently, all patients admitted through the ED receive a SARS-CoV-2 PCR test, regardless of clinical suspicion, but this was not implemented until after the study period. Lastly, there are a variety of clinical scenarios which require a negative SARS-CoV-2 PCR test prior to advancement such as, any procedure with the potential for aerosolization of respiratory secretions. But, in all cases, inpatient and outpatient testing within our system is the decision of the patient's primary provider.

The clinical virology section had an overall decrease in testing volume; however, significant changes in personnel management and testing strategies were required to respond to the demands of COVID-19. In response to the increase in demand for rapid TAT SARS-CoV-2 PCR, the virology laboratory transitioned from covering two shifts, 7 days per week, to a three-shift schedule which resulted in more

consistent and shorter TATs. The virology laboratory also discontinued viral culture methods and DFA testing for viral respiratory pathogens based on CDC and WHO recommendations.(30,31) The volume of batch testing for viral load, serology, and antigen assays for other pathogens was also decreased. These changes and the elimination of highly manual tests allowed for the redistribution of staff within the virology laboratory to accommodate needs for SARS-CoV-2 PCR testing.

Cross-coverage throughout the laboratory has also been a common point of discussion throughout the COVID-19 outbreak. We conducted a skills assessment of all laboratory staff in anticipation of the need to reassign staff to other laboratory sections to accommodate possible surges in viral molecular testing or to address COVID-19 related staff shortages. Staff who required minimal cross-training for appropriate competency to perform virology testing were trained during gaps in their schedule in case immediate reassignment was needed. The molecular diagnostics laboratory, which had a marked decline in order volume, was able to provide much needed assistance to the testing efforts in virology, particularly those related to SARS-CoV-2 PCR. Decreases in overall laboratory test volumes also allowed us to re-allocate staff across laboratory sections, but as we prepare to reopen clinical operations, normal laboratory demand will return and possibly increase, at least over the short term, with the likelihood that we will experience ongoing and likely increasing needs for COVID-19 testing, both NAAT and serologic. We anticipate new staffing models will be implemented to accommodate these shifting demands.

Local treatment protocols may include testing recommendations for the management of patients with COVID-19 and may significantly influence laboratory test utilization. At our institution, the initial recommendations for admitted adults with COVID-19 included CBC with differential, procalcitonin, CRP, LDH, BNP, troponin, D-dimer, fibrinogen, and PT/PTT at baseline and every 12 hours for the duration of admission. The data described here primarily influenced the frequency of testing for patients with COVID-19. For example, it is now a local recommendation that CRP and D-dimer are drawn

at baseline and every 12 hours for only 5 days and then daily thereafter. The remaining laboratory tests are drawn every 24 hours for 5 days with the option to extend longer if clinically indicated. These frequencies are built into the admission order panels for COVID-19 admission. Lastly, in contrast to the study period, cytokine testing is now limited to admitted patients and is ordered only at the time of admission and the time of transfer to intensive care, rather than every two days.

Literature detailing preparedness measures for responding to a surge in clinical laboratory testing is scarce. The influenza A (H1N1) pandemic of 2009 is probably the most recent and relevant precedent in the era of molecular viral testing where surge capacity was needed in clinical laboratories.(32,33) Most published accounts of laboratory surge capacity focus on the need to scale up diagnostic testing for infectious agents.(34–37) However, there are few examples in which the sudden increase in demands placed on the laboratory extended beyond disease-focused testing. Due to COVID-19 we are now acutely aware of the precarious nature of the global supply chain, including for the clinical laboratory, and future planning must incorporate the possibility of severe and prolonged supply chain disruptions. Additionally, it remains to be seen how laboratory services will be impacted by the reopening of clinical operations when we are still providing services to acutely ill COVID-19 inpatients and dramatically increasing testing capacity to meet institutional and public health needs. It is likely that COVID-19 incidence will experience at least some rebound as society reopens, and the laboratory will face continued demand for rapid and accurate diagnostic tests for COVID-19 along with more typical testing needs. Finally, it is possible that active COVID-19 transmission will occur during the traditional influenza season, further exacerbating the demands for rapid respiratory viral testing. Thus, the shifting demands on the clinical laboratory are likely to persist for the near future.

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Table 1: Change in laboratory test container utilization relative pre- and pandemic two-week time periods. Orders are collated into groups which represent the laboratory section in which the related assays are performed. Abbreviations: COVID-19 = Coronavirus Disease of 2019; GAS = Group A *Streptococcus pneumoniae*; INR = International Normalized Ratio; NT-proBNP = N-terminal pro-brain natriuretic peptide; PT = Prothrombin Time; PTT = Partial Thromboplastin Time; SARS-CoV-2 = Severe Acute Respiratory Syndrome Coronavirus.

Test Name	2/2 to 2/16	3/28 to 4/11	Absolute Difference	Relative Difference (%)
Send-out Lab				
SARS-CoV-2 (COVID-19) (PCR)	0	2303	2303	--
Cytokine Panel	5	1333	1328	26560.00
Angiotensin II Level	0	115	115	--
Chemistry				
C-Reactive Protein (CRP)	804	4700	3896	484.58
Troponin T	1460	4958	3498	239.59
Procalcitonin	635	3938	3303	520.16
Ferritin	953	4151	3198	335.57
Lactate Dehydrogenase	656	2485	1829	278.81
NT-proBNP	747	1403	656	87.82
Hematology				
D-Dimer, Quantitative	229	4286	4057	1771.62
Fibrinogen	617	3892	3275	530.79
PT/INR and PTT	1936	4312	2376	122.73
Microbiology				
Legionella / S. pneumoniae Antigen	136	203	67	49.26
Urine Culture	2409	1113	-1296	-53.80
Blood Culture	2131	1286	-845	-39.65
GAS PCR	356	11	-345	-97.91
Lower Respiratory Culture	335	292	-43	-12.84
Virology				
SARS-CoV-2 (COVID-19) (PCR)	0	3408	3408	--
Rapid Influenza A/B (PCR)	1445	267	-1178	-81.52
Respiratory Virus Panel (PCR)	855	98	-757	-88.54
Respiratory Virus Panel (DFA)	221	0	-221	-100.00
Influenza Typing RT-PCR	77	0	-77	-100.00
Blood Gas				
Blood Gas (Arterial)	1925	2388	463	24.05
Blood Gas (Venous Mixed)	356	156	-200	-56.18
Blood Gas (Venous)	298	255	-43	-14.43
POC				
Troponin I (POC)	1291	926	-365	-28.27
Chem-8 (POC)	870	592	-278	-31.95
Blood Bank				
Type and Screen	2679	1582	-1097	-40.95

Table 2: Relative change in commonly ordered tests for respiratory tract infections between pre- and pandemic state, collated into patient setting groups, as defined by ordering department.

	Overall (%)	**OP (%)**	**ED (%)**	**IP (%)**
All Laboratory Orders	-26.0	-65.0	-43.2	-0.3
Procalcitonin	542.7	77.8	50.1	876.8
Influenza PCR	-81.5	-54.1	-85.9	142.1
Legionella / S. pneumoniae Antigen	43.9	0.0	-42.2	82.4
Arterial Blood Gas	35.0	-58.8	-20.9	37.4
MRSA PCR	-15.7	50.0	-37.4	27.2
Lower Respiratory Culture	-24.1	-79.5	-86.7	-7.1
Blood culture	-39.7	-55.2	-26.6	-46.7
Respiratory Virus PCR Panel	-88.5	-98.4	-88.5	-86.0
GAS PCR	-96.9	-95.4	-98.7	-100.0

Table 3: Change in laboratory test container utilization relative pre- and pandemic two-week time periods.

Container Type	2/2 to 2/16	3/28 to 4/11	Absolute Difference	Relative Difference
Viral Transport Media	2417	6118	3701	153.1
Blue Top Tube	7523	14998	7475	99.4
Light Green Top Tube	53925	50512	-3413	-6.3
Dark Green Top Tube (Whole Blood)	631	596	-35	-5.5
Blood Spot Card	429	403	-26	-6.1
Lavender Top Tube	26006	15242	-10764	-41.4
Gold Top Tube	14368	7232	-7136	-49.7
Gray Top Tube (Urine)	4059	2031	-2028	-50.0
Red/Yellow Tiger Top Tube (Urine)	4409	2528	-1881	-42.7
Blood Gas Syringe	8477	6640	-1837	-21.7
Pink Top Tube	3876	2262	-1614	-41.6
Sterile Container	3063	1504	-1559	-50.9
Aptima Urine	2128	607	-1521	-71.5
Yellow Top Tube (Urine)	3088	1728	-1360	-44.0
Red Top Tube	2087	753	-1334	-63.9
E-Swab	2211	896	-1315	-59.5
Aerobic/Anaerobic BC Bottles	2132	1285	-847	-39.7
Gray Top Tube	1803	1211	-592	-32.8
Dark Green Top Tube (Plasma)	1578	1067	-511	-32.4
QuantiFERON-TB Plus 4-Tube Kit	452	190	-262	-58.0

FIGURE LEGENDS:

Figure 1: Laboratory test order trends plotted as a function of time, spanning the beginning of the COVID-19 outbreak in the local community of a single tertiary care medical center. **(A)** Total laboratory test orders (Left Y-axis) and COVID-19 testing and positive test results (Right Y-axis). **(B)** Core laboratory, blood gas, and point-of-care test orders (Left Y-axis); Send-out laboratory test orders (Right Y-axis). **(C)** Microbiology, virology, and specialty laboratory test orders (Left Y-axis); Blood bank test orders (Right Y-axis). Groups: Core lab = Hematology and chemistry laboratories; Specialty testing = Immunology, flow cytometry, and molecular diagnostics. Abbreviations: BG = Blood Gas; COVID-19 = Coronavirus disease of 2019; PCR = Polymerase chain reaction; POC = Point-of-care

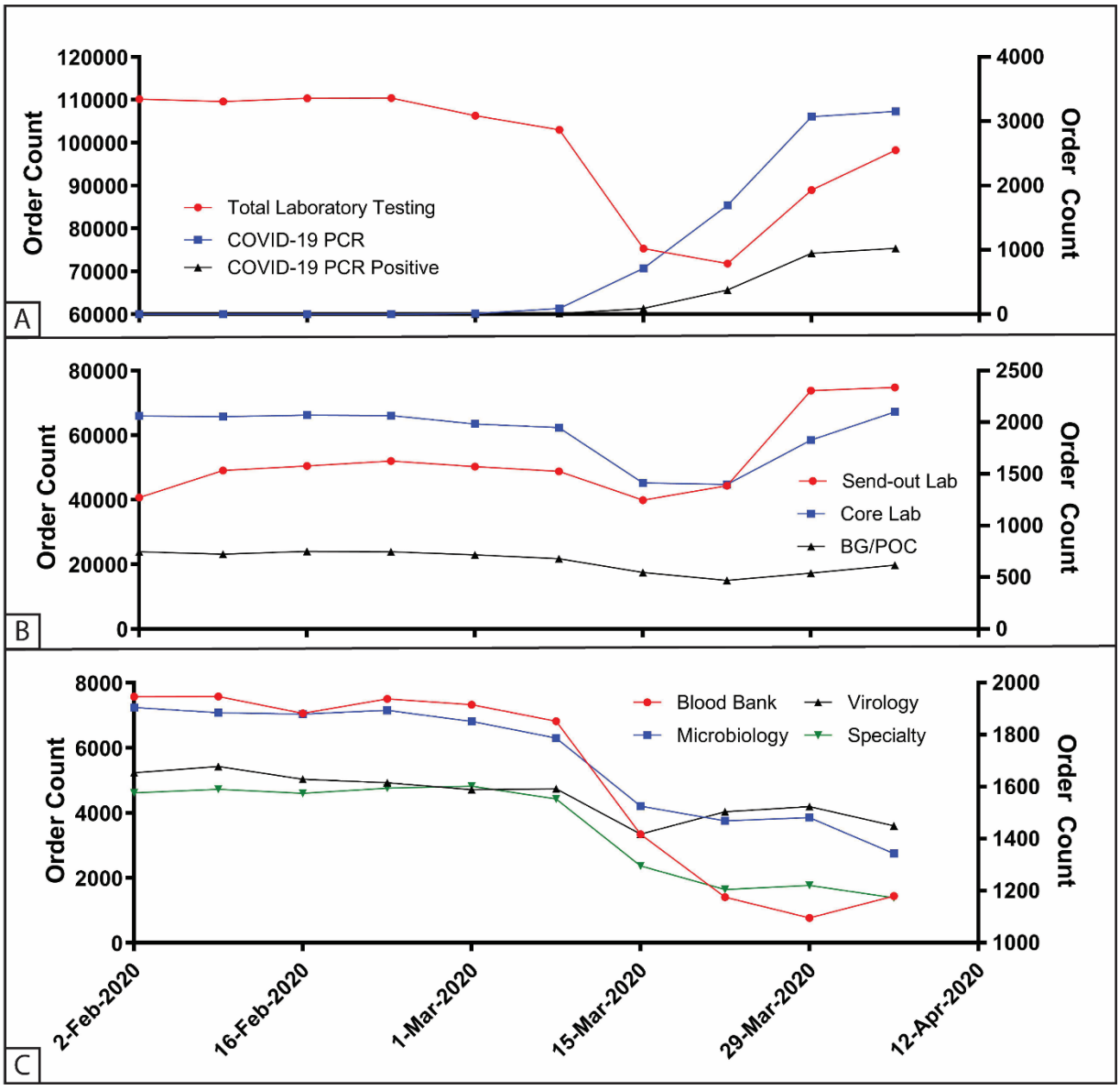

Figure 2: Changes in laboratory test order trends relative to pre- and pandemic state, collated into groups designated by resulting laboratory section. X-axis represents the percent difference between the total number of final verified test orders during the first and last two-weeks of the observation period. Abbreviations: Dx = Diagnostics.